

## REMARKS

Applicants respectfully request reconsideration of the present application in view of the foregoing amendments and in view of the reasons that follow. This amendment adds, changes and/or deletes claims in this application. A detailed listing of all claims that are, or were, in the application, irrespective of whether the claim(s) remain under examination in the application, is presented, with an appropriate defined status identifier.

### I. Introduction

Claims 75 and 76 have been cancelled. Claims 69, 74, 79 and 91-92 have been amended. Specifically, claims 69 and 79 have been amended to incorporate the limitations of cancelled claim 75, and claims 74 and 91-92 have been amended for clarification. New claims 93 -96 have been added. After amending the claims as set forth above, claims 69-71, 73-74, 77-80, 82 and 89-96 are now pending in this application. No new matter was added. Support for new claims 93 and 94 can be found on page 19, lines 4-15 and on page 21, lines 6-19 as well as in FIGS. 4A, 4B and 4I-4N of the present specification. Support for new claims 95 and 96 may be found on page 16, lines 4-6 of the specification.

### II. 35 U.S.C. §112 Rejections Should Be Withdrawn

Claims 69-71, 73-80, 82 and 89-92 are rejected under §112, ¶1 as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is more nearly connected, to make and/or use the invention. This rejection is respectfully traversed.

As noted in MPEP § 2164.08,

“...the scope of enablement must only bear a "reasonable correlation" to the scope of the claims. See, e.g., *In re Fisher*, 427 F.2d 833, 839, 166 USPQ 18, 24 (CCPA 1970). As concerns the breadth of a claim relevant to enablement, the only relevant concern should be whether the scope of enablement provided to one skilled in the art by the disclosure is commensurate with the scope of protection sought by the claims. *AK Steel Corp. v. Sollac*, 344 F.3d 1234, 1244, 68 USPQ2d 1280, 1287 (Fed. Cir. 2003); *In*

*re Moore*, 439 F.2d 1232, 1236, 169 USPQ 236, 239 (CCPA 1971).

...

Claims are not rejected as broader than the enabling disclosure under 35 U.S.C. 112 for noninclusion of limitations dealing with factors which must be presumed to be within the level of ordinary skill in the art; the claims need not recite such factors where one of ordinary skill in the art to whom the specification and claims are directed would consider them obvious. *In re Skrivan*, 427 F.2d 801, 806, 166 USPQ 85, 88 (CCPA 1970).

In the present case, the scope of enablement bears a "reasonable correlation" to the scope of the claims and the scope of enablement provided to one skilled in the art by the disclosure is commensurate with the scope of protection sought by the claims.

Specifically, independent claims 69 and 79 recite an isolated single-walled carbon nanotube (SWNT) on a substrate. One of ordinary skill in the art understands that such isolated SWNT on a substrate has a finite length of several millimeters to a few centimeters. Furthermore, one of ordinary skill in the art understands and considers it obvious that such SWNTs are by definition nanostructures and do not have a length of a foot, a yard or a mile, as suggested in paragraph 2 of the Office Action. Thus, while claims 69 and 79 do not recite an upper limit on the length of the SWNT, Applicants submit that the claims need not recite such factors where one of ordinary skill in the art to whom the specification and claims are directed would consider them obvious, as noted in the MPEP section quoted above.

Furthermore, MPEP § 2164.08 states that:

When analyzing the enabled scope of a claim, the teachings of the specification must not be ignored because claims are to be given their broadest reasonable interpretation that is consistent with the specification. "That claims are interpreted in light of the specification does not mean that everything in the specification must be read into the claims." *Raytheon Co. v. Roper Corp.*, 724 F.2d 951, 957, 220 USPQ 592, 597 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 835 (1984).

The present specification indicates that the lengths of the claimed SWNT range from 1 to a few centimeters (see for example, page 16, lines 4-6 (1 cm or more mentioned ), page 21, lines 1-13 of the specification (several mm, including 2.1 and 3.9 mm mentioned)). Thus, the claims should be given their broadest reasonable interpretation that is consistent with the specification. The present specification provides sufficient enablement for the claimed SWNTs that one of ordinary skill in the art would understand to be in the millimeter to few centimeter length range.

Furthermore, new claims 95 and 96 recite an upper limit on the length of the nanotube and are believed to be fully enabled.

### **III. 35 U.S.C. § 102(b) Rejections Should Be Withdrawn**

Claims 69-71, 73-75, 77-80, 82 and 89-92 are rejected under 35 U.S.C. 102(b) as being anticipated by Zhu (Science 3 May 2002 Vol. 296). This rejection is respectfully traversed.

Claim 75 is cancelled to simplify the issues remaining in the present application. Thus, the rejection of claims 75 is rendered moot.

#### **A. Claims 69 and 79**

Claims 69 and 79 are the only independent claims that are currently pending in this application. Claim 69 of the present application recites an individual single-walled carbon nanotube synthesized on a substrate, wherein the nanotube has a length of at least 1 mm from one end to an opposite end of the individual nanotube, and wherein the nanotube is substantially isolated from other nanotubes. Claim 79 recites a system comprising an individual single-walled carbon nanotube and multiple transistor or diode devices along the length of the nanotube, wherein the nanotube has a length of at least 1 mm from one end to an opposite end of the individual nanotube, and wherein the nanotube is substantially isolated from other nanotubes.

Applicants submit that the Zhu reference does not teach, suggest or enable an individual single-walled carbon nanotube synthesized on a substrate, wherein the nanotube has a length of

at least 1 mm from one end to an opposite end of the individual nanotube, and wherein the nanotube is substantially isolated from other nanotubes. Further, Applicants submit that the Zhu reference does not teach, suggest or enable a system comprising such a nanotube having a length of at least 1 mm with multiple devices along the length thereof.

## **B. The Zhu Reference**

Zhu teaches the growth of “SWNT strands” with lengths of 10 or 20 cm and diameters of ~0.3 mm (page 84 and Fig. 1). These strands consist of thinner SWNT ropes, which in turn consist of well-aligned SWNT bundles composed of aligned SWNTs. The strands are synthesized by a floating catalyst CVD method in a vertical furnace. However, Zhu is silent about the length of the individual SWNTs in the strands, ropes and bundles.

## **C. The Claims are Patentable over the Zhu Reference**

Zhu does not teach the limitations of claims 69 and 79. Specifically, Zhu does not teach the limitation of claims 69 and 79 wherein the nanotube is “an individual single-walled carbon nanotube” having “a length of at least 1 mm” that is “substantially isolated from other nanotubes.”

Zhu teaches the growth of long SWNT strands. While the Zhu reference provides macroscopic dimensions for these strands, it says nothing about the lengths of the individual SWNTs in the strands. Specifically, Figures 1, 2A, 3A and 3B of Zhu show the nanotube strands while Figures 2B and 2C show nanotube ropes. However, the Figures do not show individual SWNTs whose length can be calculated from the Figures or whose length is at least 1 mm.

Applicants respectfully submit that the Examiner’s assertion that Figure 1 depicts “two SWNTs [that] are substantially isolated from one another” is mistaken. Both the text within Figure 1 and the corresponding caption clearly note that the Figure depicts “SWNTs ropes” / “SWNT strands.” The caption further describes the “SWNT strands” as having “a diameter of the order of 0.3 to 0.5 mm.” Given that individual SWNTs typically have diameters of the order

of ~1 nm, the depicted strands necessarily comprise at least hundreds of thousands if not millions of SWNTs bundled together (individual and isolated SWNTs would not even be visible on the scale depicted in Figure 1).

Furthermore, the length of individual SWNTs of Zhu are not inherently 1 mm or longer for the following reasons.

### **1. Resistivity**

Zhu reports that the resistivity of the strands is  $5-7 \times 10^{-6} \Omega \cdot m$  (page 884, last column, last paragraph). This resistivity is much higher than an expected resistivity of a strand of continuous SWNT whose length extends from one end of the strand to the other end. A reasonable explanation for the lower reported resistivity is that the length of the individual SWNTs in the strand of Zhu is shorter than that of the strand.

### **2. Temperature dependence**

Zhu reports on page 884, last column, last paragraph that the temperature dependence of the resistance exhibited an upturn at 90K as the temperature is reduced. This upturn is a signature of the conduction mechanism being one involving tube-to-tube hopping, implying that the conduction paths require that electrons hop across tube-tube junctions (in a phonon assisted process) to get from one end of the fiber to the other. If the strand of Zhu contained continuous SWNTs which extended from one end of the strand to the other, then the conduction mechanism would involve conduction along the length of the continuous SWNTs rather than hopping from one SWNT to another.

### **3. Young's Modulus**

Zhu teaches that the strands have a much lower Young's modulus than that of a single SWNT. This difference in modulus can be explained if the strands of Zhu are composed of a number of much shorter SWNTs, and individual SWNTs do not extend the entire length of the strands. Specifically, page 885, last column, last paragraph of Zhu states that the "...Young's

modulus estimates for these structures [i.e., the strands] from the direct tensile tests fall short of values expected for individual nanotubes...”.

The Young’s modulus of hexagonally close packed (10, 10) SWNTs should be ~650 GPa. Since Zhu reports that the strand density is 48% (page 885, last column, last paragraph), and the modulus scales with the cross-sectional area occupied, the strand’s Young’s modulus should be ~312 GPa if SWNTs ran the entire length of the strand.

In contrast, Zhu discloses a Young’s modulus of 49 to 77 GPa which scales to only ~100 to 150 GPa if the 48% density is taken into account (sentence bridging pages 885 and 886 of Zhu). This value of ~100-150 GPa is less than half of the about 300 GPa value that Zhu would have obtained if nanotubes ran the entire length of the fiber. This difference between the Young’s modulus of Zhu’s strands and the known SWNT Young’s modulus indicates that the strands of Zhu are made up of shorter SWNTs which do not extend the entire length of the strand.

Moreover, because the Zhu reference describes a floating catalyst method in a vertical furnace, rather than growth from a substrate as disclosed in the present application, there is no basis for a presumption that the strand contains any individual SWNT having a length greater than 1 mm.

Therefore, individual SWNTs having a length of at least 1 mm are not inherent in the strands of Zhu because SWNTs of such length do not necessarily have to be present in the strands of Zhu. (See MPEP 2112(IV) which states that “The fact that a certain result or characteristic may occur or be present in the prior art is not sufficient to establish the inherency of that result or characteristic. *In re Rijckaert*, 9 F.3d 1531, 1534, 28 USPQ2d 1955, 1957 (Fed. Cir. 1993)... “To establish inherency, the extrinsic evidence ‘must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of

circumstances is not sufficient.' " *In re Robertson*, 169 F.3d 743, 745, 49 USPQ2d 1949, 1950-51 (Fed. Cir. 1999).")

Accordingly, the invention as recited in claims 69 and 79 as amended should be in condition for allowance. Dependent claims 70-71, 73-74, 77-78, 80, 82 and 89-94 should also be in condition for allowance by virtue of their dependence on allowable base claims 69 and 79.

#### **V. 35 U.S.C. § 103 Rejections Should Be Withdrawn**

Claims 69-71 are rejected under §103(a) as being unpatentable over Smalley et al. (US 6,749,827). This rejection is respectfully traversed. Claim 69 is amended to include the limitations of dependent claim 75, where the latter is not rejected under §103(a) as unpatentable over Smalley. Accordingly, the invention as recited in claim 69 as amended should be in condition for allowance. Dependent claims 70-71 should also be in condition for allowance by virtue of their dependence on allowable base claim 69.

Claims 69-71, 73-75, 77-80, 82 and 89-92 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kim ("Synthesis of Ultralong and High Percentage of Semiconducting Single Walled Carbon Nanotubes," *Nano Letters* 2002, vol. 2, no. 7, pp. 703-708). This rejection is respectfully traversed.

#### **The Kim Reference**

The Kim reference teaches the "growth of SWNTs into macroscopic lengths of up to 0.6 mm, the longest reported for isolated single-walled tubes" (p. 703, col. 1, lines 23-24). The Kim reference further teaches that such nanotubes "exhibit interesting loop and ring morphologies in their as-grown forms" (p. 703, col. 1, lines 25-26), and that "[w]hile nanotubes tens of microns long are typically relatively straight (Figure 1b), tubes that are hundreds of microns long tend to show loop structures along their length" (p. 704, col. 1, lines 7-9; see also Figure 1).

#### **The Claims are Patentable over the Kim Reference**

The Kim reference does not teach or suggest the limitations of claims 69 and 79. Specifically, the Kim reference does not enable one of ordinary skill in the art to grow “an individual single-walled carbon nanotube” having “a length of at least 1 mm.”

The Kim reference teaches growth of SWNTs having lengths of only 0.6 mm or less—only about half the length specified in claims 69 and 79 of the present application. The Kim reference moreover asserts that the 0.6 mm SWNT described therein is “the longest reported for isolated single-walled tubes.” This and other statements in the Kim reference indicate that the authors’ goal was to grow the longest SWNT possible, and that the authors would have reported growth of a 1-mm-long SWNT had such growth been enabled by the methods described therein.

Furthermore, Applicants note that the SWNTs of Kim are grown by a different method from the preferred method of the present application. While the pending product claims in the present application are not limited to the specific methods described in the present specification, the methods described in the present specification may be used to show that Kim does not enable one of ordinary skill in the art to grow millimeter or longer SWNTs. Specifically, as noted on page 16, line 4 to page 17, line 15 of the present specification, the preferred fast heating with directional gas flow method of growing SWNTs results in much longer SWNTs having lengths of at least 1 mm than the slow heating method (where the substrate is placed in the furnace and the furnace is ramped to the desired temperature). In contrast, there is no evidence that Kim uses the fast heating method with the directional gas flow. Thus, there is no evidence that Kim enables SWNT growth of greater than 0.6 mm length.

Accordingly, Applicants respectfully submit that the methods described in the Kim reference would not have enabled one of ordinary skill in the art to grow “an individual single-walled carbon nanotube” having “a length of at least 1 mm,” and that claims 69 and 79 are therefore patentable over the Kim reference.

Accordingly, the invention as recited in claims 69 and 79 as amended should be in condition for allowance. Dependent claims 70-71, 73-74, 77-78, 80, 82 and 89-94 should also be in condition for allowance by virtue of their dependence on allowable base claims 69 and 79.

Additionally, the Kim reference does not teach or suggest the limitations of new claims 93 and 94, which depend on claims 69 and 79, respectively. Specifically, the Kim reference does not teach or suggest “an individual single-walled carbon nanotube” having “a length of at least 1 mm” that is “relatively straight.” In fact, the Kim reference actually teaches away from such limitations by teaching that “[w]hile nanotubes tens of microns long are typically relatively straight (Figure 1b), tubes that are hundreds of microns long tend to show loop structures along their length.” For this additional reason, the invention as recited in claims 93 and 94 should be in condition for allowance.

Claims 73 and 76 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zhu (Science 3 May 2003 Vol. 296) or Kim (“Synthesis of Ultralong and High Percentage of Semiconducting Single Walled Carbon Nanotubes,” Nano Letters 2002, vol. 2, no. 7, pp. 703-708) or Smalley in view of Lieber et al (US 6,781,166 B2). This rejection is respectfully traversed. For the reasons stated above, claim 69 as amended is patentable over the Zhu reference, the Kim reference and the Smalley reference. Specifically, none of these references teach or suggest “an individual single-walled carbon nanotube” having “a length of at least 1 mm” that is “substantially isolated from other nanotubes.” Accordingly, dependent claims 73 and 76 should also be in condition for allowance by virtue of their dependence on allowable base claim 69.

## **VI. Conclusion**

Applicants believe that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested. The Examiner is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicants hereby petition for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 19-0741.

Respectfully submitted,

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